ORIGINAL ARTICLE

Pericapsular Nerve Group Block versus Femoral Nerve Block for Positioning during Spinal Anaesthesia in Patients with Hip Fracture: A Randomized Controlled Trial

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Abstract

Background: Hip fractures are a leading cause of morbidity in elderly patients globally. Subarachnoid block (SAB) is the preferred anaesthetic technique for surgical repair, but positioning patients for SAB causes severe pain. Peripheral nerve blocks offer effective pre-procedural analgesia. The Pericapsular Nerve Group (PENG) block is a novel motor-sparing technique targeting articular branches of the anterior hip capsule, proposed as an alternative to the conventional Femoral Nerve Block (FNB). The objective of this study was to compare the analgesic efficacy of ultrasound-guided PENG block versus FNB for positioning patients with hip fracture prior to SAB.

Methods: A randomised controlled trial was conducted in Dhaka Medical College Hospital from August 2023 to March 2025. One hundred patients (aged 45–80 years, ASA I–II) were randomised: Group F (FNB, n=50) received 0.25% bupivacaine 10 mL + 1% lignocaine with adrenaline 5 mL (15 mL total); Group P (PENG block, n=50) received 0.25% bupivacaine 10 mL + 1% lignocaine with adrenaline 10 mL (20 mL total). Primary outcomes: VAS pain score at 30 minutes post-block and pain grade during SAB positioning. Secondary outcomes: best sitting angle, performer-rated positioning quality, haemodynamic parameters, and adverse events.

Results: Baseline demographics were comparaable ($p > 0.05$). PENG block produced significantly lower VAS at 30 min (1.66±0.66 vs 2.98±1.30; $p < 0.001$); 100% of Group P achieved VAS <4 versus 70% in Group F ($p < 0.001$). Optimal sitting angle (>90°) was more frequent with PENG block (88% vs 58%; $p = 0.002$). Pain-free (Grade 1) positioning was achieved in 88% of Group P vs 36% of Group F ($p < 0.001$). Performer-rated positioning quality was superior in Group P ($p = 0.007$). Haemodynamic parameters and adverse event rates were comparable ($p > 0.05$). Number needed to treat for optimal sitting angle: 3.3.

Conclusion: PENG block is superior to FNB for pre-procedural analgesia in hip fracture patients undergoing SAB, providing better pain control, optimal positioning, and higher operator satisfaction without increased adverse effects. It should be considered the preferred regional technique for this indication at centres with ultrasound capability.

Keywords: Pericapsular Nerve Group block; Femoral Nerve Block; Hip fracture; Subarachnoid block; Positioning analgesia

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Introduction

Hip fractures are among the most prevalent and debilitating injuries affecting the elderly, with approximately 1.5 million cases

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occurring annually worldwide and incidence projected to increase substantially with global population ageing.[1] In Bangladesh and across South Asia, where age-specific incidence data remain limited, the burden is recognised as significant and rising. Hip fracture necessitates urgent surgical intervention, and appropriate perioperative pain management is critical for optimising outcomes, reducing complications, and facilitating functional recovery.

Subarachnoid block (SAB) is the preferred anaesthetic technique for hip fracture surgery, associated with lower rates of postoperative delirium, thromboembolic events, and respiratory complications compared with general anaesthesia.[2] The sitting position is commonly chosen for SAB administration due to technical ease; however, positioning patients with hip fracture in this posture is extremely painful due to the fracture itself, muscle spasm, periosteal irritation, and stimulation of the hip joint capsule. Inadequate analgesia during positioning compromises patient cooperation, increases the risk of procedural failure or multiple spinal attempts, and precipitates adverse haemodynamic responses.[3]

Systemic opioids, particularly intravenous fentanyl, have traditionally been employed for positioning analgesia. While effective to a degree, opioids carry significant risks in elderly patients with multiple comorbidities, including respiratory depression, nausea, vomiting, excessive sedation, and postoperative delirium.[3] Regional anaesthesia techniques offer a targeted, opioid-sparing alternative.

The Femoral Nerve Block (FNB), administered under ultrasound guidance, has been the most widely used regional technique for this indication. Sia et al. demonstrated FNB's superiority over intravenous fentanyl in reducing positioning pain and improving patient cooperation for SAB.[4] However, FNB induces significant motor blockade of the quadriceps, which may delay postoperative mobilisation and increase fall risk in elderly patients, limiting its utility in enhanced recovery pathways.[5]

The Pericapsular Nerve Group (PENG) block, first described by Girón-Arango et al. in 2018, represents a paradigm shift in hip analgesia.[6] It targets the articular branches of the femoral nerve (L2–L4), accessory obturator nerve (L3–L4), and obturator nerve (L2–L4) as they traverse the musculofascial plane between the psoas tendon and the pubic ramus adjacent to the anterior hip capsule. By selectively blocking sensory fibres supplying the anterior hip capsule without affecting the main motor branches of the femoral nerve, PENG block provides effective hip analgesia while preserving quadriceps motor function.[6] Lin et al. demonstrated PENG block's superior short-term analgesic efficacy compared with FNB in hip fracture surgery.[7] Despite promising international evidence, data from South Asian populations, particularly in the context of SAB positioning, remain scarce.

This randomised controlled trial was designed to provide high-quality, locally relevant evidence comparing ultrasound-guided PENG block with FNB as pre-procedural analgesia for SAB positioning in hip fracture patients at Dhaka Medical College Hospital (DMCH), Bangladesh.

Materials and methods

This was a parallel-group, single-centre, randomised controlled trial (RCT) conducted at the Department of Anaesthesia, Pain, Palliative & Intensive Care, Dhaka Medical College Hospital (DMCH), Dhaka, Bangladesh, from August 2023 to March 2025 (20 months). The study was approved by the Ethical Review Committee (ERC) of Dhaka Medical College. The trial was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants before enrolment. Adult patients aged 45–80 years, scheduled for hip fracture repair under SAB, and ASA physical status I or II were included in this study. The exclusion criteria were: allergy to study drugs; cardiac arrhythmias, heart failure, ischaemic heart disease, or atrioventricular conduction block; anatomical abnormalities of the spine or pelvis; bleeding disorders or anticoagulant therapy; psychiatric or neurological disease; infection at the block site.

Eligible patients were randomised 1:1 using 100 sequentially numbered opaque sealed envelopes prepared by a statistician not involved in data collection. Each envelope was opened in the

procedure area immediately prior to block administration. Group F (control) received ultrasound-guided FNB; Group P (study) received ultrasound-guided PENG block. Data recording was performed by a trained research assistant who was blinded to group allocation and absent from the procedure area during block administration, ensuring outcome assessment blinding.

Study Procedure

All patients received intravenous fluid preloading with warm Hartmann's solution (10 mL/kg) within 30 minutes of intravenous cannulation. Premedication comprised intravenous omeprazole 40 mg and ondansetron 8 mg and standard monitoring (ECG, SpO_2, NIBP) was established. Baseline heart rate (HR), mean arterial pressure (MAP), and VAS score during 15° passive straight leg raise (SLR) were recorded by the blinded research assistant.

All blocks were performed under aseptic conditions using a portable ultrasound machine (X-Porte, Sonosite Ltd, USA) with a 6–13 MHz linear transducer. A small intradermal wheal of 2% lignocaine was used prior to needle insertion. Both groups underwent ultrasound identification of both the femoral nerve and acetabular fossa to maintain blinding.

Femoral Nerve Block (Group F): With the patient supine, the inguinal ligament was identified as a linear hyperechoic structure. Sliding the probe caudally revealed the femoral vessels and the femoral nerve sheath (hyperechoic triangular structure lateral to the femoral artery). A 22G JMI Sononed block needle was introduced in-plane from lateral to medial at 30° to the skin, 2 cm below the inguinal ligament. After negative aspiration, 0.25% bupivacaine 10 mL + 1% lignocaine with adrenaline 1:50,000 in 5 mL (total 15 mL) was injected, with real-time spread confirmed by ultrasound.

PENG Block (Group P): The patient was positioned supine with slight external hip rotation. The anterior inferior iliac spine (AIIS) was identified by ultrasound, and the probe rotated 45° counter-clockwise to align with the pubic ramus, visualising the iliopubic eminence (IPE), iliopsoas muscle and tendon, pectineus muscle, and femoral artery. A 22G echogenic needle was advanced in-plane from lateral to medial. The needle tip was positioned in the musculofascial plane between the psoas tendon and the pubic ramus near the IPE. After negative aspiration, 0.25% bupivacaine 10 mL + 1% lignocaine with adrenaline 1:50,000 in 10 mL (total 20 mL) was injected under continuous ultrasound visualisation.

Thirty minutes after block administration, patients were transferred to the operating room. Haemodynamic parameters (HR, MAP) were recorded at baseline, immediately post-block, and at 5, 10, 15, and 30 minutes. VAS score during passive SLR (15°) was re-assessed at 30 minutes. If VAS ≥4 persisted, rescue intravenous fentanyl (1 ìg/kg) was administered in 5-minute intervals (maximum 3 doses). SAB was subsequently performed per standard protocol with confirmation of L1 sensory level and Bromage scale 2 motor blockade. The following outcomes were assessed and recorded by the blinded research assistant:

- Pain grade during positioning for SAB: Grade 1 = sitting without pain with minimal help; Grade 2 = mild pain by grimacing or verbal expression; Grade 3 = severe pain but tolerable with assistance; Grade 4 = intolerable, requiring additional analgesia.
- Best sitting angle: A = good flexion >90°; B = average flexion 70–90°; C = poor flexion <70°.
- Performer-rated quality of positioning: 0 = not satisfactory; 1 = satisfactory; 2 = good; 3 = optimal (Likert scale).
- Adverse events: haematoma, shivering, hypotension (MAP <60 mmHg), bradycardia (HR <60 bpm), arrhythmia.

Statistical analysis:

Data were analysed using IBM SPSS Statistics Version 20.0 (Chicago, IL, USA). Continuous variables were expressed as mean ± standard deviation (SD) and compared using the independent samples t-test. Categorical variables were expressed as frequencies and percentages and analysed by the Pearson chi-square test or Fisher's exact test as appropriate. Non-parametric VAS distribution was additionally characterised using median and

interquartile range (IQR) and compared with the Mann-Whitney U test. Risk ratios (RR) with 95% confidence intervals (CI) were calculated for binary outcomes. Number Needed to Treat (NNT) was derived as 1/absolute risk reduction (ARR). A p-value < 0.05 was considered statistically significant with a 95% confidence interval.

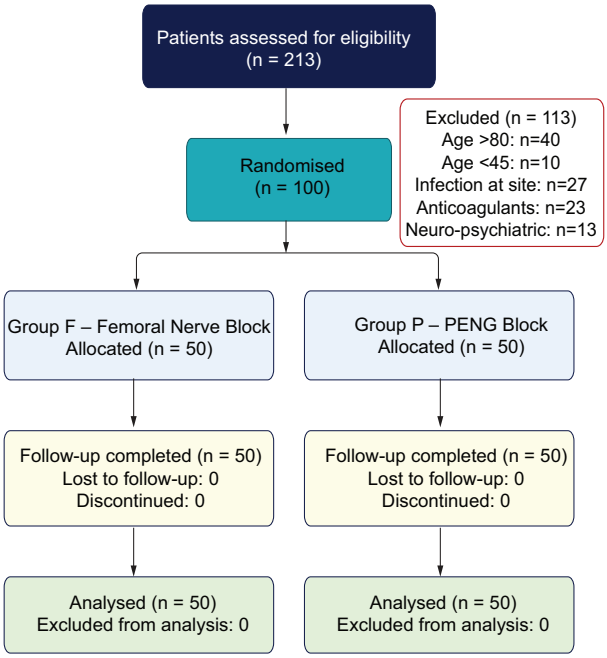

Figure 1: Consolidated Standard reporting trials (CONSORT) flow diagram

Results

Of 213 patients assessed for eligibility, 113 were excluded (40 aged >80 years; 10 aged <45 years; 27 infection at block site; 23 bleeding disorders or anticoagulation; 13 neuropsychiatric disorders). One hundred patients were randomized and all completed the study (zero dropouts or protocol deviations). The CONSORT flow diagram is presented in Figure 1. Demographic and baseline characteristics are shown in Table I. No significant statistical difference was observed between the groups.

Haemodynamic parameters were comparable at baseline between groups. A transient elevation in HR was observed in Group P immediately post-block,

Table I: Demographic and Baseline Disease Characteristics

Characteristic	Group F - FNB (n=50)	Group P - PENG (n=50)	p-value
Age (years, mean ± SD)	60.34±12.95	63.36±10.63	0.42
Sex: Male, n (%)	25 (50.0)	29 (58.0)	0.42
Waist-Hip Ratio (mean ± SD)	0.78±0.06	0.80±0.05	0.20
ASA II, n (%)	32 (64.0)	28 (56.0)	0.27
Any comorbidity, n (%)	32 (64.0)	28 (56.0)	0.67
Diabetes mellitus	8 (16.0)	10 (20.0)	—
Hypertension	9 (18.0)	6 (12.0)	—
DM + Hypertension	15 (30.0)	12 (24.0)	—
Pre-block VAS (SLR 15°), mean ± SD	9.34 ± 0.77	9.14 ± 0.86	0.236

Chi-square test for categorical variables; independent t-test for continuous variables. p < 0.05 considered statistically significant. ASA = American Society of Anesthesiologists; VAS = Visual Analogue Scale; SLR = Straight Leg Raise.

likely reflecting a sympathetic response to procedural stimulation, followed by gradual stabilisation. A mild decline in MAP at the 10-minute timepoint was noted in both groups, attributable to sympatholytic effects of local anaesthetic absorption, with recovery by 15–30 minutes. Overall haemodynamic stability was maintained in both groups with no clinically significant differences in HR or MAP at any timepoint (p > 0.05 for MAP at all timepoints; see Figure 2).

Pre-block VAS scores were equivalent between groups (Group F: 9.34 ± 0.77 vs Group P: 9.14 ± 0.86; p = 0.236), confirming comparable baseline pain severity. At 30 minutes post-block, PENG block produced significantly lower VAS scores (1.66 ± 0.66 vs 2.98 ± 1.30; p < 0.001). Crucially, 100% of Group P patients (n=50) achieved VAS < 4 compared to 70% (n=35) in Group F (p < 0.001; RR 1.43, 95% CI 1.18–1.72; NNT = 3.3). VAS distribution at 30 minutes post-block is illustrated in Figure 3.

Pain-free positioning (Grade 1) was achieved in 88% (n=44) of Group P compared to 36% (n=18) of Group F (p < 0.001; RR 2.44, 95% CI 1.64–3.65). No patient

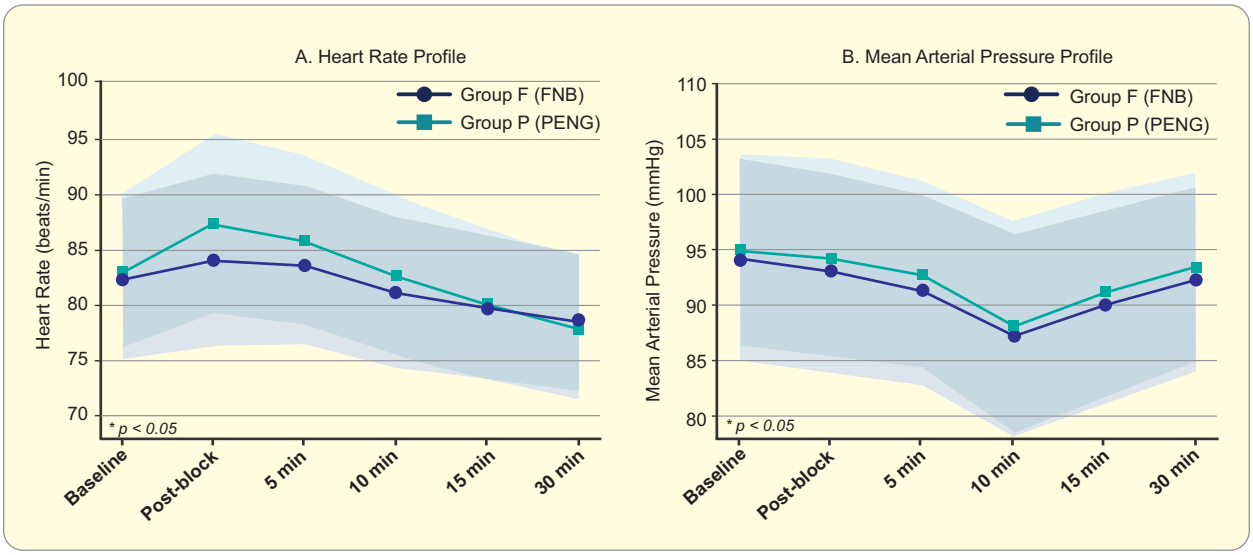

Figure 2: Haemodynamic profiles following block administration. A: Heart rate (HR); B: Mean Arterial Pressure (MAP). Shaded zones represent mean ± SD. Asterisks (*) indicate $p < 0.05$ at individual timepoints. Overall MAP difference was non-significant ($p > 0.05$ at all timepoints).

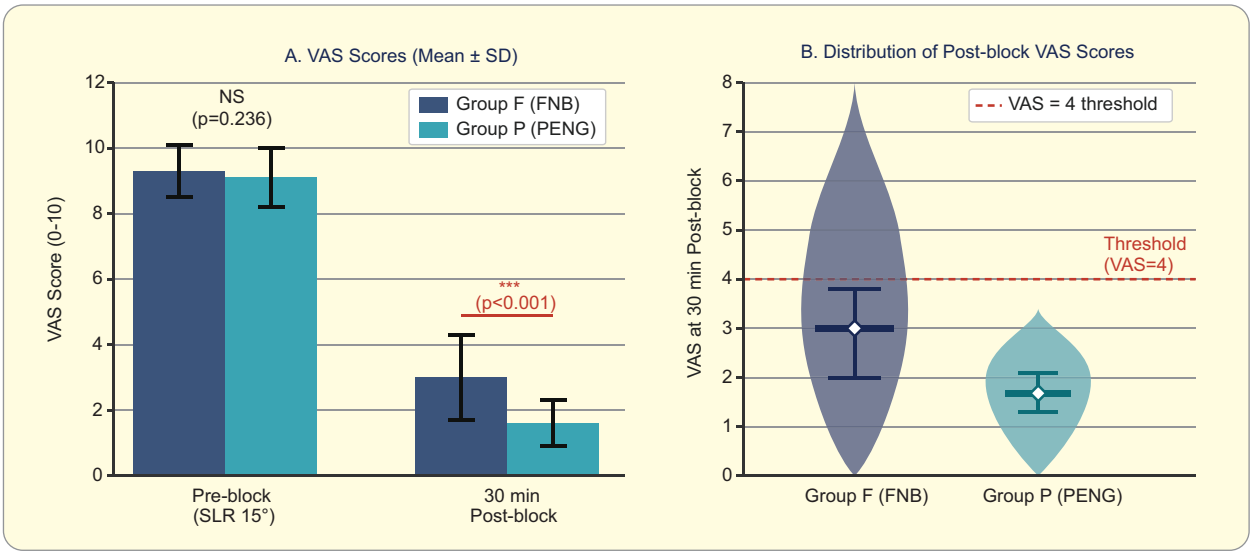

Figure 3: VAS pain scores. A: Mean ± SD pre-block and 30-min post-block (*** $p < 0.001$; NS = not significant). B: Violin plot of post-block VAS distribution. The dashed line indicates the clinically meaningful threshold of VAS = 4. The diamond marker represents the median.

in Group P experienced Grade 3 (severe) pain, compared to 20% (n=10) in Group F. The mean pain grade was significantly lower in Group P (1.12 ± 0.33 vs 1.84 ± 0.74; $p < 0.001$). Grade 4 pain requiring additional analgesia occurred in no patient in either group.(Table II)

Optimal sitting angle (>90°) was achieved in 88% of Group P versus 58% of Group F ($p = 0.002$; RR 1.52, 95% CI 1.21–1.90; NNT = 3.3). No patient in Group P had a poor sitting angle (<70°) compared with 8% in Group F. Performer-rated positioning quality was superior in Group P ($p = 0.007$), with 74% achieving 'good' or 'optimal'

ratings versus 46% in Group F. Adverse events occurred in 20% of Group P versus 32% of Group F, a difference that was not statistically significant (p = 0.25; RR 0.63, 95% CI 0.32–1.21). No case of local anaesthetic systemic toxicity, block failure, or need for general anaesthesia conversion occurred. (Table III)

Table II: Pain Assessment during positioning for SAB

Pain Grade	Group F-FNB (n=50)	Group P-PENG (n=50)	p-value
Grade 1 — Sits without pain, minimal help	18 (36.0)	44 (88.0)	< 0.001
Grade 2 — Mild pain (grimacing/verbal)	22 (44.0)	6 (12.0)	
Grade 3 — Severe pain, tolerable with help	10 (20.0)	0 (0.0)	
Grade 4 — Intolerable, additional analgesia	0 (0.0)	0 (0.0)	
Mean Pain Grade (± SD)	1.84±0.74	1.12±0.33	< 0.001

Chi-square test for grade distribution; independent t-test for mean pain grade.

Table III: Best Sitting Angle, Positioning Quality, and Adverse Events

Outcome	Group F-FNB (n=50)	Group P-PENG (n=50)	p-value
Sitting Angle			0.002
A: Good >90°	29 (58.0)	44 (88.0)	
B: Average 70–90°	17 (34.0)	6 (12.0)	
C: Poor <70°	4 (8.0)	0 (0.0)	
Performer-Rated Quality			0.007
0: Not satisfactory	2 (4.0)	0 (0.0)	
1: Satisfactory	25 (50.0)	13 (26.0)	
2: Good	16 (32.0)	17 (34.0)	
3: Optimal	7 (14.0)	20 (40.0)	
Adverse Events (any), n (%)	16 (32.0)	10 (20.0)	0.25
Haematoma at block site	3 (6.0)	2 (4.0)	—
Shivering	7 (14.0)	4 (8.0)	—
Hypotension (MAP <60 mmHg)	4 (8.0)	3 (6.0)	—
Bradycardia (HR <60 bpm)	2 (4.0)	1 (2.0)	—
Arrhythmia	0 (0.0)	0 (0.0)	—

Chi-square test for all comparisons. MAP = Mean Arterial Pressure; HR = Heart Rate.

Forest plot analysis of effect estimates across all primary and secondary endpoints is presented in Figure 4. All primary outcome measures favoured PENG block with statistically significant effects. NNT analysis (Figure 5A) identified the most clinically impactful

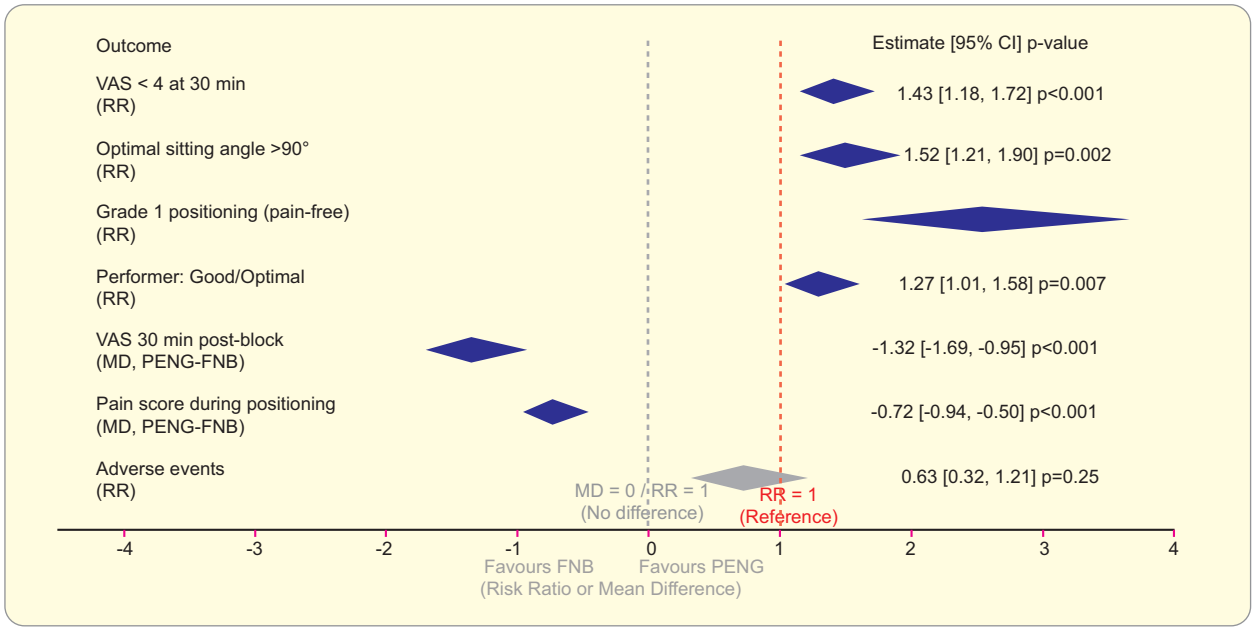

Figure 4: Forest plot of effect estimates (Risk Ratios for binary outcomes; Mean Differences for continuous outcomes) with 95% confidence intervals. Values to the right of the reference lines favour PENG block for RRs (RR >1) or indicate less pain for MDs (MD <0). The adverse events endpoint is non-significant (p = 0.25).

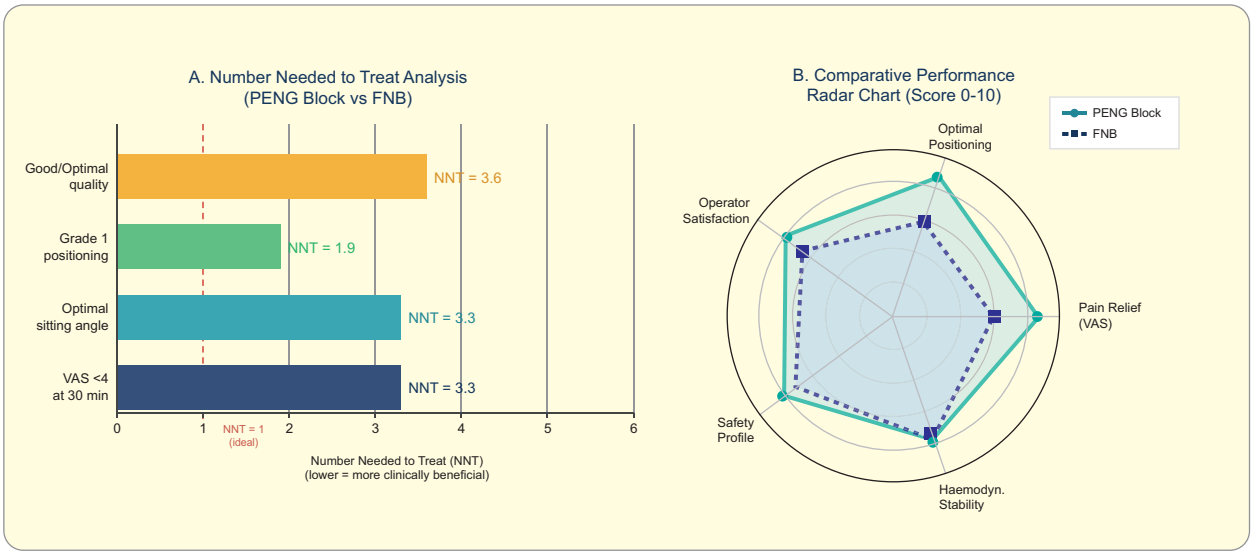

Figure 5: Clinical benefit analysis. A: Number Needed to Treat (NNT) for key outcomes favouring PENG block; lower NNT indicates greater clinical benefit. B: Radar chart comparing PENG block and FNB across five performance dimensions (scores derived from study outcomes, scale 0–10).

benefits for pain-free positioning (NNT = 1.9) and VAS <4 (NNT = 3.3). A comparative radar chart (Figure 5B) illustrates the multi-dimensional performance advantage of PENG block, particularly for pain relief and positioning outcomes, while demonstrating equivalent safety profiles.

Discussion

This randomised controlled trial provides robust, locally contextualised evidence that ultrasound-guided PENG block offers clinically and statistically superior pre-procedural analgesia compared with FNB for positioning hip fracture patients for SAB at a major tertiary hospital in Bangladesh. The findings align with and extend the international literature.

The significantly lower VAS scores at 30 minutes post-PENG block (1.66 ± 0.66 vs 2.98 ± 1.30; $p < 0.001$) and the 100% achievement of VAS < 4 in Group P versus 70% in Group F correspond closely with Lin et al. (2021), who reported that 63% of PENG block patients experienced no pain in the immediate postoperative period versus 30% in the FNB group.[7] The VAS difference in our study (MD -1.32, 95% CI -1.69 to -0.95) exceeds the commonly accepted minimal clinically important difference (MCID) of approximately 1.3 cm on a 10-cm VAS, confirming clinical as well as statistical significance.[8]

The substantially higher rate of Grade 1 (pain-free) positioning in Group P (88% vs 36%; NNT = 1.9) has direct practical implications. Effective positioning is a prerequisite for successful SAB; inadequate analgesia leads to patient movement, increased technical difficulty, a greater number of spinal attempts, delayed theatre time, and heightened haemodynamic stress responses in a population already at cardiovascular risk. These findings are consistent with Alrefaey and Abouelela (2020), who similarly demonstrated PENG block's superiority for positioning pain in a randomised Egyptian cohort.[9]

The significantly greater achievement of optimal sitting angle (>90°) in Group P (88% vs 58%; NNT = 3.3; $p = 0.002$) and superior performer-rated quality scores ($p = 0.007$) reflect the functional translational benefit of PENG block's analgesic efficacy. Both metrics capture real-world procedural utility in a way that complements the VAS data, providing a more complete picture of clinical benefit consistent with Liang et al.'s findings on enhanced recovery after hip arthroplasty.[10]

The mechanism underlying PENG block's superior efficacy in this context is anatomically rational. The anterior hip capsule, which is the principal pain

generator during hip flexion for SAB positioning, receives sensory innervation predominantly from articular branches of the femoral nerve (L2–L4), accessory obturator nerve, and obturator nerve converging at the IPE.[6] PENG block targets precisely this plexus of articular branches in the musculofascial plane, achieving dense anterior capsular analgesia. FNB, while blocking the main femoral nerve trunk, is less selective and may provide less complete coverage of the multi-source articular innervation of the hip capsule.[6,7]

Haemodynamic stability was comparable between groups throughout the observation period (MAP $p > 0.05$ at all timepoints), with minor HR differences at certain timepoints that were not clinically meaningful. Adverse event rates were comparable (20% vs 32%; $p = 0.25$; RR 0.63, 95% CI 0.32–1.21), and no serious complications, block failures, or local anaesthetic systemic toxicity events occurred in either group. This confirms that PENG block's analgesic superiority is not achieved at the expense of safety, consistent with Hua et al.'s safety data for PENG block in elderly hip arthroplasty patients.[11]

This study has several limitations that warrant acknowledgement. The sample size (n=100) was smaller than the statistically calculated target (n=556) due to resource constraints; while the achieved sample demonstrated statistically significant differences for all primary outcomes, larger studies would provide more precise effect estimates and greater generalisability. Drug volumes were fixed rather than weight-adjusted, representing a pragmatic limitation imposed by patient inability to stand for weighing. The single-centre design at DMCH, while providing internal validity, may limit external generalisability to centres with different patient populations or block expertise. Long-term outcomes, including chronic pain, functional recovery, and quadriceps strength (a proposed motor-sparing benefit of PENG block not formally assessed in this trial), warrant evaluation in future studies.

Conclusion

Ultrasound-guided PENG block is superior to Femoral Nerve Block as pre-procedural analgesia for positioning hip fracture patients for subarachnoid block. It achieves significantly better pain control (NNT for VAS <4 = 3.3), higher rates of optimal sitting angle attainment (NNT = 3.3), and superior performer-rated positioning quality, without increasing adverse effects. PENG block should be adopted as the preferred regional analgesic technique for this indication at centres with ultrasound capability. Future multicentre trials incorporating motor function assessment, opioid consumption data, and long-term functional recovery endpoints are recommended to consolidate these findings.

Declaration:

Ethics approval: The study was approved by the Ethical Review Committee, Dhaka Medical College, Dhaka, Bangladesh [ERC-DMC/ECC/2023/219].

Author contributions

Conception and development of the idea: SKM, IJ
Writing: IJ, SI
Data analysis: IJ, SAK, SI, IA
Data collection: IJ, RBS, KN, IA
Review and Editing: SKM, IJ
Funding: No external funding was received for this study.
Conflict of interest: We have no conflicts of interest.

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